<u>CLAIMS</u>:

1.   A method of effecting magnetic resonance experiments comprising:

providing a location for a sample mounted in a static magnetic field,

providing adjacent to the location a transmit coil for generating a required radio-frequency magnetic field, said field being created by the coil carrying radio-frequency current of required frequency, amplitude and phase, said requirements being essentially independent of changes in the electrical characteristics and electrical and physical environment of the coil;

providing a transmitter for creating a radio-frequency signal of said required frequency that produces in the transmit coil a radio-frequency current that generates a radio-frequency magnetic field, the transmitter including a radio-frequency amplifier for setting its said signal to a desired average size, and a modulator that enables the said radio-frequency signal to be set in amplitude and phase by a known value of signal input to the modulator that serves as a measure of the said signal's amplitude and phase;

providing a current detector for supplying values of the amplitude and phase of the actual radio-frequency current in the said transmit coil;

providing adjacent to the location of the sample a receive coil for receiving a radio-frequency signal from the sample generated in response to the transmitted radio frequency magnetic field and the static magnetic field;

providing a receiver for receiving and presenting for analysis the received radio-frequency signal from the receive coil , said receiver including an amplifier for amplifying its radio frequency-signal;

wherein the transmit coil is arranged to be energised by the transmitter with a transmit radio-frequency signal of the required frequency and of which there is a known measure

of amplitude and phase;

wherein the transmit coil is arranged to be connected to a current detector which provides a measure of the amplitude and phase of current in the transmit coil;

wherein the method includes:

measuring the current in the transmit coil with said current detector to provide values of the amplitude and phase of the current;

comparing in a comparison step the transmitter's known value of signal input, that serves as a measure of required amplitude and phase, with the values of the amplitude and phase of the measured current, to determine a difference therebetween;

using the said difference to reset the amplitude and phase of the transmit radio-frequency signal input such that the amplitude and phase of the current in the coil are to high accuracy equal to the required value.

2.   The method according to claim 1 wherein the transmit coil and the receive coil are one and the same.

3.   The method according to claim 1 or 2 wherein, during the time of transmission when it is usually inactive, the receiver functions as the current detector.

4.   The method according to any one of claims 1 through 3 wherein there is a plurality of transmitting coils, each transmitting coil having its own independent transmitter and current detector for setting the amplitude and phase of its current to its required value.

5.   A method of effecting magnetic resonance experiments comprising:

providing a location for a sample mounted in a static magnetic field;

providing adjacent to the location a transmit coil for generating a required radio-frequency magnetic field, said field being created by the coil carrying radio-frequency current of

required frequency, amplitude and phase, said required values being also required functions of time, but essentially independent of changes in the electrical characteristics and electrical and physical environment of the coil;

providing a transmitter for creating a radio-frequency signal of said required frequency that produces in the transmit coil a radio-frequency current that generates a radio-frequency magnetic field;

the transmitter including:

a radio-frequency amplifier for setting its said signal to a desired average size,

a quadrature modulator that enables the said radio-frequency signal to be modulated in amplitude and phase in a manner that can be represented by a pair of orthogonal, modulator-input voltage vectors T_I and T_Q,

and a pair of filters that output said voltage vectors T_I and T_Q and that receive as inputs the differences, V_{pI} minus V_{sI} and V_{pQ} minus V_{sQ}, between two pairs of orthogonal input voltage vectors V_{pI} and V_{pQ} and V_{sI} and V_{sQ};

providing a current detector for supplying values of the amplitude and phase of the actual radio-frequency current in the said transmit coil, the said detector including a quadrature demodulator to generate two orthogonal output voltage vectors V_{sI} and V_{sQ} which are a scaled measure of the amplitude and phase of the current in the said transmit coil and which are passed to the said pair of filters as a part of the said differences;

providing adjacent to the location of the sample a receive coil for receiving a radio-frequency signal or signals from the sample generated in response to the transmitted radio frequency magnetic field and the static magnetic field;

providing a receiver for receiving and presenting for analysis the received radio-frequency signal from the receive coil , said receiver including an amplifier for amplifying its radio frequency signal;

wherein the transmit coil is arranged to be energised by the transmitter with a transmit radio-frequency signal of the required frequency, the required radio-frequency current in the coil being represented by the transmitter orthogonal input voltage pair V_{pI} and V_{pQ} that are functions of time;

wherein the transmit coil is arranged to be connected to the said current detector which provides two orthogonal output voltage vectors V_{sI} and V_{sQ} which are scaled measures of the amplitude and phase of the actual current in a transmit coil;

wherein the method includes:

measuring the actual current in the transmit coil;

supplying with said current detector for the coil a value of the measured current in the transmit coil, the amplitude and phase of which are represented by the two orthogonal voltage vectors V_{sI} and V_{sQ};

comparing in a comparison step the two orthogonal voltage vectors V_{sI} and V_{sQ}, which are representative of the measured current in the transmit coil, with the two orthogonal voltage vectors V_{pI} and V_{pQ} which are functions of time and representative of the required current in the transmit coil, to determine a difference therebetween;

feeding the comparisons as difference signals $V_{pI} - V_{sI}$ and $V_{pQ} - V_{sQ}$ through identical filters with outputs T_I and T_Q respectively;

and feeding the filtered comparison signals T_I and T_Q to the quadrature modulator of the transmitter and hence to the said transmit coil so as to constitute a feedback

circuit such that the amplitude and phase of the radio-frequency current in the coil are, to high accuracy equal to the required value;

including providing a phase adjustment means, anywhere within the electrical signal loop that constitutes the feedback circuit, to adjust the phase of signals so that the feedback is negative.

6.   The method according to claim 5 wherein the transmit coil and the receive coil are one and the same.

7.   The method according to claim 5 or 6 wherein the receiver incorporates a quadrature demodulator and functions, during the time of transmission when it is usually inactive, as the current detector.

8.   The method according to any one of claims 5 through 7 wherein negative group delay circuitry is employed to lessen the delay of the passage of electrical signals through the feedback circuit.

9.   The method according to any one of claims 5 through 8 wherein the   .
transmitter and current detector are so designed as to function in a high magnetic field.

10.   The method according to any one of claims 5 through 9 wherein there is a plurality of transmitting coils, each transmitting coil having its own independent transmitter and current detector arranged so as to constitute an independent feedback circuit.

11.   The method according to any one of claims 5 through 10 whereby all or a portion of the functions of detection, modulation, comparison and filtering are performed by digital circuitry.

12.   A method of effecting magnetic resonance experiments comprising:

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providing a location for a sample mounted in a static magnetic field;

providing adjacent to the location a transmit coil for generating in the sample a

required radio-frequency magnetic field;

providing a transmitter that creates a radio-frequency current in a transmit coil so

as to generate the required radio-frequency magnetic field;

providing adjacent to the location of the sample a receive coil for receiving a first

radio-frequency signal voltage from the sample, generated in response to the transmitted radio-

frequency magnetic field and the static magnetic field;

providing a voltage injector circuit for injecting a second radio-frequency signal

voltage into, or in series with, the receive coil, the injector circuit including a radio-frequency

attenuator for setting said second signal voltage to a desired average size, and a quadrature

modulator that enables the said second radio-frequency signal voltage to be modulated in

amplitude and phase in a manner that can be represented by a fraction of two orthogonal input

voltage vectors S_{rI} and S_{rQ};

providing a receiver for receiving, amplifying and presenting as output for

analysis a measure of the sum radio-frequency voltage in the receive coil, said receiver including

an amplifier for amplifying said radio-frequency voltages, a quadrature demodulator for phase-

quadrature detection to generate two orthogonal voltage vectors V_{rI} and V_{rQ} which are

representative of the amplitude and phase of the sum radio-frequency voltage in the said receive

coil, and a pair of filters with inputs V_{rI} and V_{rQ} that output, as the said measure, filtered

orthogonal voltage vectors S_{rI} and S_{rQ} for analysis;

wherein to render the orthogonal voltage vectors S_{rI} and S_{rQ} essentially

independent of the electrical characteristics and electrical and physical environment of the

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receive coil, the receive coil is arranged to receive the first signal from the sample and the second signal from the voltage injector:

the receive coil being connected to the receiver input,

and the receiver output being connected to the input of the voltage injector;

wherein the method includes:

applying the sum radio-frequency voltage that is at the receive coil to the receiver;

supplying an amplified value of the sum voltage to a demodulator for phase-quadrature detection to generate two orthogonal voltage vectors V_{rI} and V_{rQ} which are representative of the amplitude and phase of the sum voltage at the receive coil;

filtering the two orthogonal voltages V_{rI} and V_{rQ} to generate filtered signals S_{rI} and S_{rQ} suitable for analysis;

feeding the filtered signals S_{rI} and S_{rQ} to the modulator of the voltage injector ;

feeding the radio-frequency output of the voltage injector to the said receive coil so as to constitute a feedback circuit such that the signals for analysis S_{rI} and S_{rQ} are to high accuracy independent of the changes in electrical characteristics and electrical and physical environment of the receive coil;

13.   The method according to claim 12 wherein the transmit coil and the receive coil are one and the same.

14.   The method according to claim 12 or 13 wherein negative group delay circuitry is employed to lessen delay of the passage of electrical signals through the feedback circuit.

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15.   The method according to any one of claims 12 through 14 wherein the receiver and voltage injector are so designed as to function in a high magnetic field.

16.   The method according to any one of claims 12 through 15 wherein the transmitter functions, during the time of reception when it is usually inactive, as the voltage injector.

17.   The method according to any one of claims 12 through 16 whereby there is provided a plurality of receive coils, each receive coil having its own independent receiver and voltage injector arranged so as to constitute an independent feedback circuit.

18.   The method according to any one of claims 12 through 17 whereby all or a portion of the functions of detection, modulation and filtering are performed by digital circuitry.